Notes on Gobiidae (Teleostei) from soft bottoms of the Portuguese coast

by

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ABSTRACT. - In the past 20 years a total of 14 gobiid species were caught, by LNETI/INETI researchers, in five coastal ecosystems on soft bottoms of the Portuguese coast. Species distribution and ecological significance of species abundance are discussed.

RÉSUMÉ. - Notes sur les Gobiidae (Teleostei) des fonds meubles de la côte portugaise.

Pendant les vingt dernières années, 14 espèces de Gobiidae ont été capturées par des chercheurs de LNETI/INETI dans cinq écosystèmes de la côte portugaise, sur des fonds meubles. La distribution et la signification écologique de l'abondance des différentes espèces sont discutées.

Key words. - Gobiidae - ANE - Portugal - Coastal ecosystems - Records.

Our knowledge of Portuguese coastal ichthyofauna has greatly improved during the past three decades due to the work of various researchers. Research has been focused on estuarine community structure and function including Tagus (Costa, 1982), Mira (Almeida, 1988), Mondego (Jorge, 1991) and Sado estuaries (Lopes da Cunha, 1994). Along with estuaries the Portuguese coast has many lagoon environments whose ichthyofauna has also been studied, including Ria de Aveiro (Arruda *et al*., 1988; Rebelo, 1992), Óbidos Lagoon (Gordo and Cabral, 2001), Albufeira Lagoon (Antunes and Lopes da Cunha, 1993), Santo André Lagoon (Bernardo, 1990), Ria de Alvor (Antunes *et al.,* 1988) and Ria Formosa (Monteiro, 1989; Ribeiro *et al*., 2006).

The present paper deals with the occurrence patterns of gobies on the Portuguese coast, relying mainly on data gathered in the past twenty years, on five coastal ecosystems: Figueira da Foz coast, Estoril coast, Albufeira lagoon, Sado estuary and Ria de Alvor (Fig. 1). Gobiids have been widely recognized as an important element in estuarine ecosystems, mainly in food webs, as prey of other fish species (*v.g*. Costa, 1982; Cunha, 1984; Hamerlynck *et al*., 1986) and as a potentially useful indicator of environment degradation (Lopes da Cunha and Antunes, 1999).

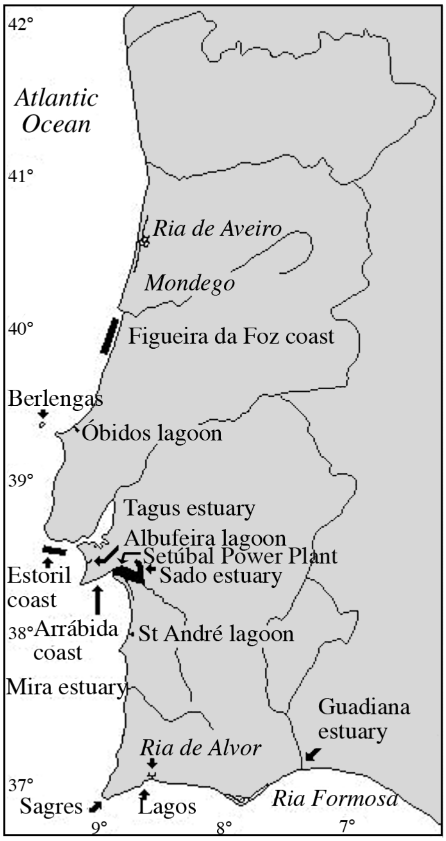

Figure 1. - Location of studied ecosystems and sites mentioned in the text. *[Localisation des écosystèmes étudiés et des sites mentionnés dans le texte.]*

METHODOLOGY

For each ecosystem the relative importance of each gobiid species was calculated as the percentage by numbers, n% (Tab. I) and the frequency of occurrence, "f" as Gs/Ts, where "Gs" is the number of samples where the species "G" was caught and "Ts" the total number of samples made (Tab. II). Whilst "n%" is dependent of relative numbers of all species caught (total equals always 100), "f" is independent for each

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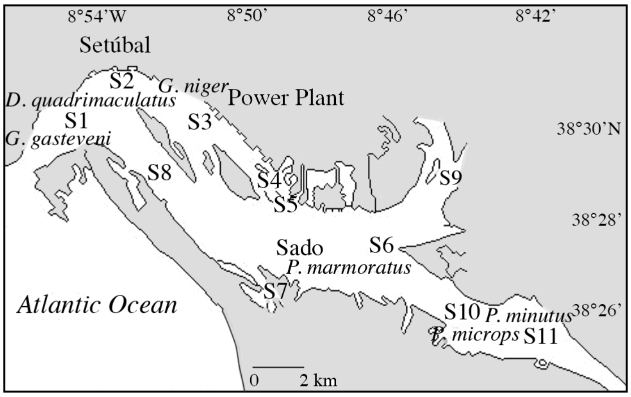

Figure 2. - Location of sampling sites in Sado estuary (S1-S11) and schematic distribution of the Gobiidae species. *[Localisation des sites d'échantillonnage dans l'estuaire de la Sado (S1-S11) et distribution schématique des espèces de Gobiidae.]*

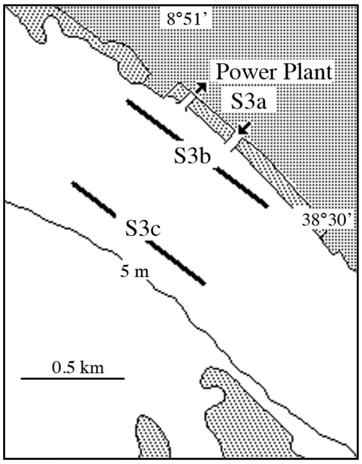

Figure 3. - Location of sampling stations (S3a-S3c) in front of Setúbal Power Plant in 1994. *[Localisation des stations d'échantillonnage (S3a-S3c) devant Setúbal Power Plant en 1994.]*

species. Comparison among species spatial distributions were made with the Renkonen index (Hamerlynk *et al.*, 1986): S = 100 - ∑ abs [(As% - Bs%)/2], where "As%" is the percentage of species "s" in site "A" and "Bs%" the same in site "B".

Sampling sites

Sampling was done in five different ecosystems whose location can be seen in figure 1. Other sites where gobies captures were reported are also shown in smaller case. Morphology, physical characteristics and sampling methodology were as follows:

Figueira da Foz coast. - Stretch of coast between rivers Mondego and Lis (Fig. 1). Samples were made with an otter trawl (mesh size: 2 cm) at monthly intervals between September 1986 and September 1987. Between 1995 and 2005 only summer time samples were made with the same fishing gear. Coarse sand was the main substratum near shore, changing to fine sand with increasing depth (Rodrigues and Quintino, 1988). A low organic content was observed. Strong swell was present most of the time. Samples were taken always in depths inferior to 20 m.

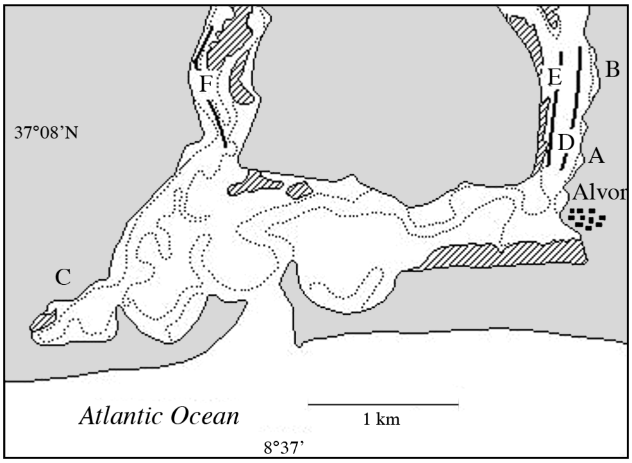

Figure 4. - Sampling location in Ria de Alvor (A-E). Hachured areas correspond to salt marshes. *[Localisation de l'échantillon à Ria de Alvor (A-E). Les zones hachurées correspondent aux marais salants.]*

Estoril Coast. - A stretch of coast with a general east-west orientation (Fig. 1). Muddy sediment was frequently observed in the trawl. Strong waves were present frequently in the western part of the prospected region. Samples were taken at depths between 80 to 100 m, with a commercial otter trawl (mesh size: 2 cm), at irregular intervals between 1997 and 2005.

Albufeira Lagoon. - Small water body characterized by high density of aquatic vegetation (*Zostera* sp.). Communication with the Ocean was interrupted by winter storms and artificially restored in the spring. Sediment included sand near shore and mud in the middle (Quintino and Rodrigues, 1989). Samples were made, monthly, between January 1985 and December 1996 with a beach seine (mesh size: 1 cm) and did not reach more than 3 m depth. Results are presented separately for 1985 and 1986 because in this last year the communication with the ocean was interrupted much of the time.

Sado estuary. - Sado estuary present a complex patchy sediment with coarse sediment near the mouth and near the south margin, and an increase proportion of mud upstream and near the north margin (Rodrigues and Quintino, 1990). North margin in heavily industrialised which results in high organic matter inputs. Salinity is most of the time at ocean's level. Fish were obtained in three different periods. In 1983 and 1984 samples were made on the filtering drums of Setúbal's Power Plant (Lopes da Cunha and Peneda, 1985). Between 1987 and 1989 samples were made, monthly at 11 stations, with a 4 m beam trawl (mesh size: 1 cm) (Fig. 2). In 1994 samples were made in the filtering drums of Setúbal's Power Plant and at two distances from shore and during day and night, at low and high tide (Fig. 3).

Ria de Alvor. - Ria de Alvor is a very small and shallow estuary due to strong silting. However communication with the ocean was always effective. Sediment was mainly medium sand but mud was present on the two arms and in the small bay at the Southwest corner (Fig. 4). Green algae and small patches of sea grass were present. Samples were made with a beach seine (1-3; Fig. 4) and a 4 m beam trawl (4-6; Fig. 4), both gears with a mesh size of 1 cm.

RESULTS

Gobiidae captures

Figueira da Foz coast. - In this region the dominant species was always *Pomatoschistus lozanoi* (Tab. I). However in the first period (September 1986-September 1987) *Aphia minuta* represented 16.5% of the total against only 1.0% from 1995 to 2005. This difference is related to the temporal occurrence of this species, which is more common in the spring. Samples made in April yielded 71.8% of the total number of specimens caught. Between 1995 and 2005 samples were made only in the summer, reducing the probability of capturing this species. A reduction of frequency of occurrence was also evident between the two periods (Tab. II). Only two more gobiid species were caught in this ecosystem, *Pomatoschistus minutus* and *Gobius niger*, represented by single specimens. Percentage of gobies specimens in relation to benthic species was low, 14.6% and 13.5%, for the two periods studied, respectively.

Estoril coast. - In Estoril coast captures were made at approximately 90 m depth, revealing the presence of only five gobiid species. The dominance of *Lesueurigobius sanzoi* was very high reaching 97.8% of the gobies. This species along with *Lesueurigobius. friesii* was not caught in any other studied ecosystem. Gobies were equivalent to 10.0% of all benthic species.

Albufeira lagoon. - This ecosystem had a rich gobiid component including nine species (Tab. I). In 1985 the most abundant species were *Gobius niger* (52.0%) and *Pomatoschistus microps* (33.3%). Two other species were common, *Pomatoschistus marmoratus* (9.3%, f = 0.31) and *Gobius paganellus* (3.3%, f = 0.35). In 1986 the closing of the lagoon lowered the salinity to 11 ‰ and induced anoxic conditions in central and deeper region. *G. niger* increased dominance, reaching 70.6%, whilst *Pomatoschistus* spp. decreased. *P. microps* seemed to sustain better the reduction in salinity (17.7%, f = 0.57) than *P. marmoratus* (1.5%, f = 0.07). *G. paganellus* increased its presence to 8.0% and f = 0.46. It is probable that the reduction of dissolved oxygen in the deeper waters forced fishes to the near shore, were beach seine sampling was more effective.

Sado estuary. - In the first period, when samples were only obtained from the filtering drums of Setúbal Power Plant, *Pomatoschistus* genus was the dominant gobiid species. This group included most probably a mixture of *P. microps* and *P. marmoratus*. In the second period, based on beam trawl samples, the most abundant species was *P. minutus* equivalent to 54.7% of gobies. However this species was caught preferentially in the upstream station (S11, Fig. 2), with 84.5% there. *G. niger* was also abundant reaching 25.8% and f = 0.65 (Tabs I, II). This species was more common in the north margin characterized by organic enrich-

Table I. - Percentage by numbers. BS: beach seine; BT: beam trawl; Bta: id. Near shore; Btb: id. Middle channel; FD: filtering drums of Setúbal Power Plant; OT: otter trawl; *: *P. microps + P. marmoratus*. *[Pourcentage en nombre.]*

	Percentage by numbers											
Ecosystem	Figueira da Foz coast		Estoril coast	Albufeira lagoon		Sado estuary					Ria de Alvor estuary	
Fishing gear	OT	OT	OT	BS	BS	FD	BT	FD	BTa	BTb	BS	BT
Year	1986-87	1995-05	1997-05	1985	1986	1983-84	1987-89	1994	1994	1994	1985-86	1985-86
Aphia minuta	16.5	1.0	0.4	0.1	0.3	0.9	0.9	9.3	0.1			0.1
D. quadrimaculatus						0.03	0.9					
Gobius cobitis				0.4	0.2							
G. gasteveni			0.2				0.8					
G. niger		0.1		52.0	70.6	2.5	25.8	7.6	88.4	94.2	45.8	87.4
G. paganellus				3.3	8.0	0.05	0.03				0.6	0.3
Gobiusculus flavescens				0.5	0.7							
Lesueurigobius friesi			0.5									
L. sanzoi			97.8									
Pomatoschistus lozanoi	83.5	98.8	1.1									
P. marmoratus				9.3	1.5		3.7	2.7	0.1	0.2		0.6
P. microps				33.3	17.7	94.2*	8.9	68.4	0.6	0.2	53.2	10.7
P. minutus		0.1		1.0	0.9	0.8	54.7	2.2	10.7	4.2		0.1
P. pictus				0.3	0.1	1.5	4.3	9.8	0.1	1.0	0.2	0.7

Table II. - Frequency of occurrence. BS: beach seine; BT: beam trawl; BTa: id. Near shore; BTb: id. Middle channel; FD: filtering drums of Setúbal Power Plant; OT: otter trawl. *[Fréquence d'occurrence.]*

	Frequency of occurrence											
Ecosystem	Figueira da Foz coast		Estoril coast	Albufeira lagoon		Sado estuary					Ria de Alvor estuary	
Fishing gear	OT	OT	OT	BS	BS	FD	BT	FD	BTa	BTb	BS	BT
Year	1986-87	1995-05	1997-05	1985	1986	1983-84	1987-89	1994	1994	1994	1985-86	1985-86
Aphia minuta		0.02	0.04	0.02	0.04		0.14	0.17	0.06			0.03
D. quadrimaculatus							0.08					
Gobius cobitis				0.06	0.06						0.05	
G. gasteveni			0.02				0.08					
G. niger		0.02		0.77	0.83		0.65	0.08	1.00	0.94	0.85	0.52
G. paganellus				0.35	0.46		0.01				0.13	0.05
Gobiusculus flavescens				0.05	0.03							
Lesueurigobius friesi			0.04									
L. sanzoi			0.79									
Pomatoschistus lozanoi		0.72	0.08									
P. marmoratus				0.31	0.07		0.20	0.13	0.06	0.03		0.05
P. microps				0.40	0.57		0.26	0.27	0.20	0.03	0.49	0.16
P. minutus		0.02		0.08	0.12		0.45	0.02	0.74	0.33		0.03
P. pictus				0.06	0.02		0.33	0.13	0.03	0.12	0.03	0.08

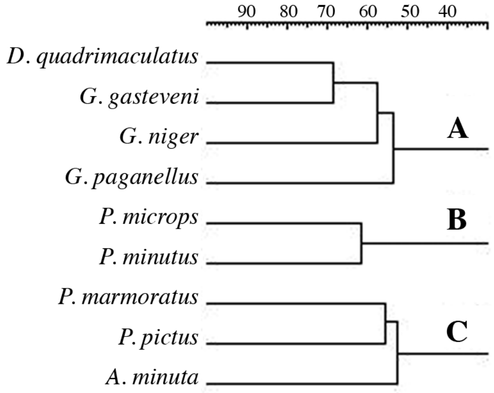

Figure 5. - Comparison of spatial distribution of gobiids in Sado estuary. *[Comparaison de la distribution des gobidés dans l'estuaire de la Sado.]*

ment (stations S2 and S3; Fig. 2). Other three *Pomatoschistus* were relatively common, *P. microps* (8.9%), *P. pictus* (4.3%) and *P. marmoratus* (3.7%). *P. microps* was caught preferentially in upstream stations, S11 (52.3%) and S10 (28.0%). *P. pictus* was evenly distributed with a maximum of 20.2% in station S9. *P. marmoratus* was more abundant in stations S6 (27.9%), S7 (26.2%) and S9 (21.7%). *Deltentosteus quadrimaculatus* was exclusive of Sado estuary and was caught mainly in high salinity stations, S1 and S2. Comparing species spatial distribution inside Sado estuary the existence of three main groups was evident (Fig. 5). The first (A) included species caught preferentially in down stream and organic enriched stations, *D. quadrimaculatus*, *Gobius gasteveni*, *G. niger* and *G. paganellus*. The upstream group (B) was formed by *P. minutus* and *P. microps*. An intermediate group (C) included *P. marmoratus*, *P. pictus* and *Aphia minuta*.

Ria de Alvor. - A total of 8 gobiid species were caught in this ecosystem. The most common species were *G. niger* and *P. microps* (Tab. I). A strong difference was observed between captures made with beam trawl and beach seine. In beam trawl samples *G. niger* corresponded to 87.4% and *P. microps* to only 10.7%. On beach seine *P. microps* reached 53.2% and *G. niger* 45.8%. This difference is related to sampling location. In fact beach seine samples made in a very shallow embayment (Fig. 4, station 3) yielded 70.2% of the total number of this species.

Species notes

Aphia minuta (Risso, 1810). - This species has a pelagic behaviour (Miller, 1986). It was sampled in all ecosystems but generally in very low numbers. Other captures in Portuguese coast included Ria de Aveiro, Mondego estuary, Tagus estuary, Mira estuary and Ria Formosa.

Deltentosteus quadrimaculatus (Valenciennes, 1837). - Exclusive species of Sado estuary, caught in the near mouth stations, mainly in the summer months. Seems not to be a common species as it was recently reported from Ria de Aveiro by Rebelo (1992). In December 2006 a specimen of that species was caught in Estoril coast in beam trawl samples at about 40 m depth.

Gobius cobitis Pallas, 1814. - This is a rare species, which seems to prefer sites with aquatic vegetation. According to Henriques *et al*. (1999), it is common on rock, occurs also in intertidal pools (Gibson, 1970) and has a cryptic behaviour. It was also caught or observed in Mondego estuary, Sesimbra coast (Arruda, 1979, Gomes and Almeida, 1979), Arrábida coast and Santo André lagoon.

Gobius gasteveni Miller, 1974. - This species was misidentified as *G. auratus* by Lopes da Cunha (1994). In Sado estuary it was almost confined to the near ocean stations. It is probable that it will reveal more common in the near future. Henriques *et al.* (1999) refer a gobiid species that, according to their description, is most probably *G. gasteveni*.

Gobius niger Linnaeus, 1758. - This is by far the most common gobiid species as it was caught in almost all sampling sites. Our data showed that this species is very adaptable preferring organic enriched sites and/or vegetated ones. *G. niger* has been recorded from virtually all coastal Portuguese ecosystems: Ria de Aveiro Mondego estuary, Óbidos lagoon, Tagus estuary, Sesimbra coast, Arrábida coast, Sado estuary (Sobral, 1981), Mira estuary and Ria Formosa.

Gobius paganellus Linnaeus, 1758. - It was a somewhat rare species, excluding Albufeira lagoon where numbers were relatively high. However this species has been caught/observed in many coastal ecosystems albeit in lower numbers when compared with *G. niger*. Records are as follows: Ria de Aveiro, Mondego estuary, Berlengas (Almeida, 1996), Tagus estuary, Sesimbra coast, Arrábida coast (Beldade *et al.*, 2006), Santo André lagoon, Mira estuary and Ria Formosa.

Gobiusculus flavescens (Fabricius, 1779). - Exclusive of Albufeira lagoon this species was caught in very low numbers. A few captures were made on Portuguese coast; Berlengas, Sesimbra coast, Arrábida coast, Mira estuary and Lagos coast.

Lesueurigobius friesii (Malm, 1874). - This species seems not recorded recently, from the Portuguese coast. Only three specimens were caught in Estoril coast.

Lesueurigobius sanzoi (de Buen, 1918). - This species was very common in Estoril coast and seems to be a high depth gobie (approximately 90 m). A single specimen caught by a commercial trawl near Ria Formosa at a depth of 70-100 m was examined by Almeida and Gomes (1978).

Pomatoschistus lozanoi (de Buen, 1923). - This species is very similar to *P. minutus* and was observed for the first time on the Portuguese coast by Arruda and Azevedo (1987). *P. lozanoi* was clearly the dominant gobiid in Figueira da Foz coast on low organic content sandy sediment. The species is also known from Mondego estuary.

Pomatoschistus marmoratus (Risso, 1810). - This species is characteristic of confined environments but seems to be less resistant to low salinity than *P. microps*. Only a few references mention this species on the Portuguese coast; Arrábida coast and Mira estuary.

Pomatoschistus microps (Krøyer, 1838). - This is one of the most common gobiid species on the Portuguese coast. It prefers very shallow water and can be underestimate in samples taken at higher depths. Captures occurred in Ria de Aveiro, Mondego estuary, Óbidos lagoon, Tagus estuary, Santo André lagoon, Mira estuary, Ria Formosa and Guadiana estuary (Vieira *et al.*, 2002).

Pomatoschistus minutus (Pallas, 1770). - It was the first and, for many years, the only *Pomatoschistus* species recognized in Portuguese waters including a sub-species *"lozanoi"* (Albuquerque, 1954-1956). In our samples, it was abundant only in Sado estuary and in upstream sites. It was recorded from almost every estuary and lagoon on the Portuguese coast: Ria de Aveiro, Mondego estuary, Óbidos lagoon, Estoril coast, Tagus estuary, Mira estuary and Ria Formosa.

Pomatoschistus pictus (Malm, 1865). - This species is perhaps the easiest one to identify in the *Pomatoschistus* genus due to four double spots on the sides. Dorsal fins have very regular round dots. It seems that the species was recognized for the first time, in Sado estuary by Cunha (1984). Since then *P. pictus* captures have been reported from various coastal ecosystems: Ria de Aveiro, Mondego estuary, Óbidos lagoon, Arrábida coast, Mira estuary and Ria Formosa.

Other gobiid species from Portuguese coast. - Other gobiid species have been reported from various coastal sites on the Portuguese coast. These tend to be characteristic from rocky substratum and show frequently a cryptic behaviour. The fishing gears more frequently used by researchers (beam trawl and beach seine) are not suitable for the capture of such species. These rocky bottom species are not studied in the present paper.

DISCUSSION

The samples made in five different ecosystems revealed the presence of 14 gobiid species. There is a sharp difference between coastal environments for one part and more enclosed ones, like estuaries and lagoons, in what concerns species present and relative importance of the Gobiidae family. Estoril coast data is based on samples made at high depths that can hardly be considered as "coastal" (~90 m). *L. sanzoi* and *L. friesii* were the characteristic species of this site. Depth ranges reported by Miller (1986) are 47-100m for the first and 10-130m for the second species, which explains, partially, the absence of *L. sanzoi* in all the other studied systems. In Figueira da Foz coast the presence of *P. lozanoi* is largely dominant whilst in the near Mondego estuary (Fig. 1), *P. minutus* and *P. microps* were present in large numbers (Leitão *et al.*, 2006). This data suggests that there is a spatial segregation between the very similar species, *P. lozanoi* and *P. minutus*. However these two species are sympatric in the Belgian coast (Hamerlynck and Cattrijsse, 1994). It is worth mention that in these two ecosystems, Figueira da

Foz and Estoril, the proportion of gobiid specimens in relation to benthic fish was low, less than 15%. On the other three studied ecosystems gobiid fish were the main benthic family by numbers, in excess of 70%. *Pomatoschistus minutus* and *P. lozanoi* constitute a challenge in what concerns systematics. The species were separate according to cephalic papillae. However in some Sado specimens it was observed that one cheek belonged to "*minutus*" type and the other to "*lozanoi*". The mixture of "*minutus*" and "*lozanoi*" characteristics in some specimens was also observed by Hamerlynck *et al*. (1986). This situation deserves future attention.

Other very complex situation arises from the difficulty of identifying specimens previously assigned to *G. auratus*. Recently, Arruda and Almeida (1998) identified those specimens as *G. xanthocephalus* Heymer & Zander, 1972. However the specimens caught in Sado estuary present white spots on the cheeks which are only present in *G. gasteveni* (Miller, 1986).

The number of Gobiidae species on the Portuguese coast reaches, presently, 26. Albuquerque (1954-1956) listed 13 species, including however, *Lesueurigobius suerii* (Risso, 1810) that seems not to have been caught in Portuguese coast, until now. It is expectable in the near future that new research would increase our present knowledge on species distribution, biology and ecology of this important group of species.

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